Terrestrial Carbon Cycle

Reservoirs

Soils	1600 GTC
Vegetation	600 GTC
Total	2,200

Turnover Time

Vegetation: 5 to 20 years
Soils: 20 to 40 years. However using ^{14}C to date the age of soils will show much older organic matter. This is because most organic matter decomposes in the first few years leaving only a little each year to be put into long term storage.

The Balance Today

Human activities are upsetting the global carbon balance in several ways:

1) changes in the area of agricultural land
2) changes in the age structure of forests
3) Changes in atmospheric chemistry that affects vegetation.
4) These changes are of course superimposed on long-term climate variability.

Land Use Change

Today $1/5^{th}$ of the world is cropland. As forests are cleared to make cropland carbon is released to the atmosphere both by burning of the vegetation that formerly occupied the land surface and also because changes in land use tend to speed the oxidation of soil organic carbon, releasing it to the atmosphere.

Since 1980, the net flux of carbon from the terrestrial biosphere has been 0.6 to 2.5 GTC/year. Of this land change in the tropics is thought to be 1.6±1.0 GTC/year.

Forest Stands

Young to middle age forest stands sequester carbon while older stands do not as the amount of carbon they lose to decomposition is balanced by new growth. Forests of the Northern Hemisphere mid-latitudes which where harvested in the early to middle portions of this century are still regrowing and thus sequestering carbon. The rate of this sequestration is thought to be ~0.7 to 0.8 GTC/ year during the 1980's. However, some researchers feel that

it is also necessary to account for the wood that was harvested so the sequestration effect could be much lower with some researchers suggesting it is about 0. The IPCC (1994) estimates are that this NH regrowth is sequestering 0.5±0.5 GTC/year.

Changes in natural cycles of forest, insect infestation, blight, etc. also have to be considered. For it is thought that the Boreal Forests of Canada during recent times have gone from a net sink to net source of carbon due to increased fires and insect problems that might in turn be related to the increase in recent temperatures. It's a very complex system!!!

Ecosystem Metabolism

Each year 5% of the lands total carbon is exchanged with the atmosphere via photosynthesis (120 GTC/year). This value is basically a balance between the amount of photosynthesis and respiration by both plants and animals hence any changes in either of these global processes will change the net carbon fluxes:

NEP = GPP – Ra – Rh
NPP = GPP – Ra
NEP = NPP – Rh

Where NEP is *Net Ecosystem Productivity*, NPP is *Net Primary Productivity,* Ra is *autotrophic respiration* (plants) and Rh is *heterotrophic respiration* (animals).

A major question is how these relationships change as the world's climate changes. My first reaction would be that as temperatures go up so does respiration leading to higher carbon dioxide levels. However increases in atmospheric carbon dioxide may cause increased plant growth and sequestering of carbon in vegetation. At some point (~1000 ppmv) this effect will not continue as CO2 fertilization becomes saturated.

Pollution effects

- Pollutants often reduce photosynthesis – take the effects of acid rain on forests in the northeast. Acid rain is the product of the release of SO2 by power plants farther to the west.
- Also nitrogen deposition from atmospheric pollutants could also be a major effect as N is limiting in many terrestrial ecosystems.
- Tropospheric ozone could also be a problem.

Soils

Soils are also affected by land use changes. Human activities tend to lead to a loss of carbon from soils. In general, both logging and cultiviation tend to release carbon. This is do to several factors:

- Higher soil temperatures
- Increased aeration
- Increased soil moisture
- Decreased plant residues
- Increasing decomposition

Very few areas of intensive agriculture see an increase in soil carbon as result of cultivation (though this would be great!). Most of the soil carbon loss is not to rivers (by erosion) but is lost directly to the atmosphere. Adequate knowledge of the amount of soil carbon lost because of land-use changes is hard to come because it is necessary to constrain to poorly known quantities:

1) Areal extent of natural ecosystems converted to cropland
2) Percentage loss of carbon from undisturbed soil profiles

Some numbers

- 30% of the carbon is lost during the first 20 years of cultivation
- 21% of the world's soil carbon is found in tropics forests
- 34% of the world's soil carbon is found in forests soils
- 29% of the world's soil carbon in temperate grasslands

Also we are know draining wetlands so are converting areas that were net carbon sinks to net carbon sources. It is thought that wetlands were sequestering 0.14 GTC/year and are now a net source 0.03 GTC /year.